DOCUMENT RESUME

ED 167 850 CG 013 235

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TITLE The Functional Approach to Determining the Physical Requirements of Jobs.
PUB DATE 28 Aug 78
NOTE 14p.; Paper presented at the Annual Convention of the American Psychological Association (Toronto, Ontario, Canada, August, 1978); Marginally legible due to some small print

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Employment Qualifications; Individual Characteristics; Industrial Personnel; *Job Placement; *Job Skills; *Labor Conditions; Laborers; *Skill Analysis; *Task Performance

ABSTRACT

Estimation techniques of physical capacities have been used by the United States Employment Service for a period of 40 years. In one technique, benchmarks are used to define 27 different capacities and 27 working conditions, which are ultimately consolidated into six groups of the former and seven groups of the latter. The benchmarks are actual statements of work behaviors involving the characteristics. Several behaviors from a variety of jobs are used to indicate the presence of an ordinary amount as well as a critical amount of the characteristic. Although this technique was originally undertaken to facilitate the selective placement of the handicapped, the technique could be used across the board and would be equally useful for all placements. (Author)

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ED167850

American Psychological Association

86th Annual Convention
Toronto, Ontario, Canada

Symposium: Assessing Performance in Physically Demanding Work

THE FUNCTIONAL APPROACH TO DETERMINING THE PHYSICAL REQUIREMENTS OF JOBS

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Dominion Ballroom North
Sheraton Centre
Toronto, Ontario
August 28-31, 1978

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Brief History

The enabling legislation that created the United States Employment Service in 1936, the Wagner-Peyser Act, required that all workers seeking employment be placed in jobs suitable to their capacities, physical as well as mental. Hence, from the very beginning, the United States Employment Service has been concerned with physical capacities of workers and physical requirements of jobs and the appropriate relating of the two in order to meet the implicit criteria of suitability.

Needless to say, when the work was begun in 1936, little was known about either. Most of the information available was anecdotal and reflected placements that involved unique talents, exceptional motivation, or very special matching, such as placing deaf persons in printing establishment jobs where the noise was very great. Comprehensive and systematic data was needed and obtaining it became part of the job analysis program. Figure 1 shows the early data gathering worker characteristics form, an adaptation of Viteles' psychograph, which was used in determining job requirements. Out of 47 characteristics, about 15 in the first part of the list are concerned with physical strength, coordination and discrimination, and further along, beginning with item 41, attention is given to hazardous conditions, unpleasant conditions, height, and weight. As can be noted, the characteristics are, in a sense, observable traits. The measurement of each characteristic was a judgment expressing the extent it was believed distributed in the general population. Thus, the judgment that an "A" amount was required meant that a very great amount of the trait was required, such as would be possessed by not more than 2% of the general population. A "B" amount was an estimate of a distinctly above average amount of the trait, an amount possessed by 30% of the population. A "C" amount was less than that possessed by the highest 30% of the general population. Since, when in doubt as between C and B or B and A, the rater was instructed to rate B, significant requirements were the B requirements, that is, an amount believed possessed only by the top 30% of the population. Figure 2 shows the results for a Cherry Pitter.

The analyst was required to clearly describe and justify the aspects of the job rated B or A. To reduce subjectivity and ambiguity in rating, the raters were given intensive training in rating procedures and the use of a manual which, for each characteristic, provided examples that illustrated significant amounts of a particular trait. Training involved having many raters rate a single job, followed by discussion of inconsistencies in ratings to ultimately ensure agreement.

I have dwelt on this estimation procedure since, with minor modifications, it served as a pattern for the procedures used in subsequent years and in the research on functional occupational classification.

The worker characteristics check list proved inadequate to meet the needs for placing the handicapped, and so a more extensive and detailed work sheet was developed and used for many years. This work sheet consisted of

Figure 1

JOB ANALYSIS

Form ES-267
(Rev. 2-44)

Budget Bureau No. 11-R083.1
Approval Expires Feb. 28, 1945

WAR MANPOWER COMMISSION
BUREAU OF MANPOWER UTILIZATION

WORKER CHARACTERISTICS FORM

Job Title COLOR MATCHER Schedule No. _____

Indicate the amount of each characteristic required of the worker in order to do the job satisfactorily by putting an X in the appropriate column. Following are the definitions of each level:

O—The characteristic is not required for satisfactory performance of the job.

C—A medium to very low degree of the characteristic is required in some element or elements of the job.

B—An above-average degree of the characteristic is required, either in numerous elements of the job or in the major or most skilled element.

A—A very high degree of the characteristic is required in some element of the job.

When in doubt between A and B, rate B; when in doubt between B and C, rate B; when in doubt between C and O, rate C. If some characteristic not on this list is required, write it in, rate it, and define it briefly at the bottom of the form.

Amount				Characteristics Required	Amount				Characteristics Required
O	C	B	A		O	C	B	A	
X				1. Work rapidly for long periods.			X		26. Arithmetic computation.
X				2. Strength of hands.			X		27. Intelligence.
X				3. Strength of arms.			X		28. Adaptability.
X				4. Strength of back.			X		29. Ability to make decisions.
X				5. Strength of legs.		X			30. Ability to plan.
	X			6. Dexterity of fingers.			X		31. Initiative.
	X			7. Dexterity of hands and arms.	X				32. Understanding mechanical devices.
X				8. Dexterity of foot and leg.			X		33. Attention to many items.
	X			9. Eye-hand coordination.		X			34. Oral expression.
X				10. Foot-hand-eye coordination.	X				35. Skill in written expression.
X				11. Coordination of both hands.		X			36. Tact in dealing with people.
X				12. Estimate size of objects.	X				37. Memory of names and persons.
		X		13. Estimate quantity of objects.	X				38. Personal appearance.
	X			14. Perceive form of objects.		X			39. Concentration amidst distractions.
X				15. Estimate speed of moving objects.		X			40. Emotional stability.
	X			16. Keenness of vision.	X				41. Work under hazardous conditions.
X				17. Keenness of hearing.			X		42. Estimate quality of objects.
X				18. Sense of smell.	X				43. Unpleasant physical conditions.
X				19. Sense of taste.				X	44. Color discrimination.
X				20. Touch discrimination.	X				45. Ability to meet and deal with public.
X				21. Muscular discrimination.	X				46. Height.
		X		22. Memory for details (things).	X				47. Weight.
		X		23. Memory for ideas (abstracts).					48. _____
X				24. Memory for oral directions.					49. _____
X				25. Memory for written directions.					50. _____

Figure 2

Amounts of Characteristics			Characteristics Required of Worker	Amounts of Characteristics			Characteristics Required of Worker
C	B	A		C	B	A	
	X		1. Work rapidly for long periods	X			27. Intelligence
X			2. Strength of hands	X			28. Adaptability
X			3. Strength of arms	X			29. Ability to make decisions
X			4. Strength of back	X			30. Ability to plan
X			5. Strength of legs				
	X		6. Dexterity of fingers	X			31. Initiative
	X		7. Dexterity of hands and arms	X			32. Understanding of mechanical devices
X			8. Dexterity of foot and leg	X			33. Attention to many items
	X		9. Eye-hand coordination	X			34. Oral expression
X			10. Foot-hand-eye coordination	X			35. Skill in written expression
X			11. Coordination of independent movements of both hands	X			36. Tact in dealing with people
X			12. Estimate size of objects	X			37. Memory of names and persons
X			13. Estimate quantity of objects	X			38. Personal appearance
X			14. Perceive form of objects	X			39. Concentration amidst distractions
X			15. Estimate speed of moving objects	X			40. Emotional stability
X			16. Keenness of vision	X			41. Work under hazardous conditions
X			17. Keenness of hearing	X			42. Estimate quality of objects
X			18. Sense of smell	X			43. Work under unpleasant physical conditions (quality) _____
X			19. Sense of taste	X			44. Color discrimination
X			20. Touch discrimination	X			45. Ability to meet and deal with public
X			21. "Muscular" discrimination				46. Height
X			22. Memory for details (things)				47. Weight
X			23. Memory for ideas (abstract)				48. _____
X			24. Memory for oral directions				49. _____
X			25. Memory for written directions				50. _____
X			26. Arithmetic computation				

FIGURE 28
Pattern for Cherry Pitter on Worker Characteristics Form

27 physical capacities and 27 working conditions as shown in Figure 3. This was the worksheet that provided the data for the development of job families, that is, placement opportunities for persons with specified handicaps.

In 1950, when research was undertaken on the functional occupational classifications on 4,000 jobs, the physical demands and working conditions list was consolidated, as shown in Figure 4. The consolidation occurred as a result of noting that certain factors were generally rated in association with others. For example, when climbing was indicated as significantly present in a job, balancing was usually noted in the same way. The factors were illustrated with benchmarks developed during the earlier work that had proved to be effective in rating. Effectiveness was judged by experience (not statistics) from job analysis work done in the field. Figure 5 shows an example of the benchmarks for "stooping, kneeling, crouching and crawling."

Over the years, some additions and deletions have been made to these benchmarks to conform with contemporary experience, as may be noted in the manuals published in 1961 and 1972.

Reliability and Validity of Estimates

In the functional occupational classification research, 4,000 jobs were rated from job descriptions using the manuals described. The rating method was designed to overcome the major types of rating errors, namely, (a) halo effect, (b) errors of leniency and central tendency, and (c) logical errors. Logical errors in which raters tend to force all ratings into a single logical pattern were avoided by having several raters rate similar kinds of jobs randomly distributed among them. Errors of leniency and central tendency were avoided by having ratings for each job reviewed by at least one additional analyst, resulting, in effect, in a group rating. Halo effects were countered by the use of specific benchmarks for significance and nonsignificance, and requiring the analyst to justify significant ratings.

To establish the reliability and validity of the ratings, a study was designed to compare the ratings made from definitional material in the manner indicated with ratings made directly from observations in establishments in the field; 560 jobs in 20 different types of establishments in the occupational categories indicated in Figure 6 were thus studied, for which estimates made by trained analysts from job descriptions were not available. Some 60 jobs were eventually dropped from the comparison, leaving 500 jobs on the basis of which calculations were made.

The field analyst was trained in the same way as analysts working from job descriptions and, in fact, rated approximately 750 job definitions. In addition, he was given an additional week of training in techniques involved in making ratings from direct observation, methods of compiling data, and statistical treatment of results. An additional 50 jobs were then rated by the field analyst using job definitions as the source of information, having them reviewed for consistency with manual procedures, and comparing them for consistency with the consensus of research ratings for the same 50 jobs.

Figure 3

APPENDIX I

Form ES-267 (Reverse)
(Rev. 2-44)

PHYSICAL DEMANDS FORM

Job Title COLOR MATCHER Occupational Code

Dictionary Title

Firm Name & Address

Industry Industrial Code

Branch Department

Company Officer Analyst Date

PHYSICAL ACTIVITIES			
X 1	Walking	O 16	Throwing
O 2	Jumping	O 17	Pushing
O 3	Running	O 18	Pulling
O 4	Balancing	O 19	Handling
O 5	Climbing	O 20	Fingering
O 6	Crawling	O 21	Feeling
X 7	Standing	X 22	Talking
X 8	Turning	X 23	Hearing
O 9	Stooping	X 24	Seeing
O 10	Crouching	X 25	Color Vision
O 11	Kneeling	O 26	Depth Perception
X 12	Sitting	O 27	Working Speed
X 13	Reaching	O 28	
X 14	Lifting	O 29	
O 15	Carrying	O 30	

WORKING CONDITIONS			
X 51	Inside	O 66	Mechanical Hazards
O 52	Outside	O 67	Moving Objects
O 53	Hot	O 68	Cramped Quarters
O 54	Cold	O 69	High Places
O 55	Sudden Temp. Changes	O 70	Exposure to Burns
O 56	Humid	O 71	Electrical Hazards
O 57	Dry	O 72	Explosives
O 58	Wet	O 73	Radiant Energy
O 59	Dusty	O 74	Toxic Conditions
O 60	Dirty	X 75	Working with Others
O 61	Odors	X 76	Working Around Others
O 62	Noisy	O 77	Working Alone
X 63	Adequate Lighting	O 78	
X 64	Adequate Ventilation	O 79	
O 65	Vibration	O 80	

DETAILS OF PHYSICAL ACTIVITIES:

Talks with supervisor concerning daily work orders and transmits orders to workers. Stands at work table when mixing colors, reaching for pigments and dyestuffs and taking them down from shelves. Walks among workers and discusses results obtained during addition of color to stock. Sits at desk when studying order specifications and recording personnel data. Employs keen eyesight and color vision in mixing, matching and inspecting color.

DETAILS OF WORKING CONDITIONS:

Works indoors in a well-lighted, adequately ventilated room.

DETAILS OF HAZARDS:

None. Prohibited from carrying and lighting matches due to the inflammability of nitrate plastic materials.

Figure 4

U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION

Physical Demands and Environmental Conditions

ESTAB. JOB TITLE Director, Univ. Extension ESTAB. & SCHED. NO. 052-260-1-6

DOT TITLE AND CODE 090.118

PHYSICAL DEMANDS

1. STRENGTH

a. Standing 10 %
Walking 10 %
Sitting 80 %

b.

	Weight	
Lifting	NP	
Carrying	NP	
Pushing	NP	
Pulling	NP	

2.	CLIMBING	NP
	BALANCING	NP
3.	STOOPING	NP
	KNEELING	NP
	CROUCHING	NP
	CRAWLING	NP
4.	REACHING	NP
	HANDLING	NP
	FINGERING	NP
	FEELING	NP
5.	TALKING	
	Ordinary	F
	Other	NP
	HEARING	
	Ordinary Conversation	NP
	Other Sounds	NP
6.	SEEING	
	Acuity, Near	NP
	Acuity, Far	NP
	Depth Perception	NP
	Accommodation	NP
	Color Vision	NP
	Field of Vision	NP

P. D.: (S) L M H VH 2 3 4 (5) 6

ENVIRONMENTAL CONDITIONS

1. ENVIRONMENT

Inside 100 %

Outside ____ %

2.	EXTREME COLD WITH OR WITHOUT TEMPERATURE CHANGES	NP
3.	EXTREME HEAT WITH OR WITHOUT TEMPERATURE CHANGES	NP
4.	WET AND/OR HUMID	NP
5.	NOISE Estimated maximum number of decibels	65 db.
	VIBRATION	NP
6.	HAZARDS	
	Mechanical	NP
	Electrical	NP
	Burns	NP
	Explosives	NP
	Radiant Energy	NP
	Other	NP
7.	ATMOSPHERIC CONDITIONS	
	Fumes	NP
	Odors	NP
	Dusts	NP
	Mists	NP
	Gases	NP
	Poor Ventilation	NP
	Other	NP

E. C.: (I) O B 2 3 4 5 6 7

Stooping, Kneeling, Crouching and/or Crawling

These activities are described as:

Stooping.- Bending the body downward and forward by bending the spine at the waist.

Kneeling.- Bending the legs at the knees to come to rest on the knee or knees.

Crouching.- Bending the body downward and forward by bending the legs and spine.

Crawling.- Moving about on the hands and knees or hands and feet.

The activities in this factor involve full use of the lower extremities as well as the back muscles. Therefore, stooping should not be rated when the worker is performing this act while in a sitting position.

Sample Situations that Would Be Rated for Stooping, Kneeling, Crouching, and/or Crawling

CHARWOMAN (any ind.). Stoops, kneels, crouches, crawls to sweep and scrub floors. This involves continuous use of back and leg muscles. Frequently stoops and crouches to dispose of waste and litter and to polish fixtures and fittings.

WEEDER (agric.). Continuously stoops and crouches to remove weeds by hand or with hoe.

LOADER AND UNLOADER (tobacco). Frequently stoops and crouches to load and unload boxes, bales, and hogsheads onto and from vehicles, making full use of back and leg muscles.

Sample Situations that Would Not Be Rated for Stooping, Kneeling, Crouching, and/or Crawling

TUBE SORTER (rubber reclaim.). Intermittently stoops during working day to sort tubes according to color. Stoops slightly from either standing or sitting position when reaching for inner tubes in order to cut metal valve pads from them. This activity does not involve any unusual demand upon the back and leg muscles.

EXECUTIVE CHEF (hotel & rest.). Occasionally stoops to handle food, utensils, and cutlery when inspecting food preparation. Stooping activities are incidental to the primary job duties of planning meals and supervising cooks.

Figure 6

TABLE 1

Industrial and Skill Level Distribution of Jobs

*S.I.C. Code	Industry	D. O. T. Major Groups Title and Code							Totals
		Profess. 0	Cler. Sales 1	Service 2	Agricul. 3	Skilled 4-5	Semi-Sk. 6-7	Un-Sk. 8-9	
3614	Elec. Motor & Generator	6	13	2	0	11	25	5	62
2311	Men's Suits	2	6	3	0	5	27	0	43
2051	Bread & Bakery Prod.	7	7	2	0	13	15	27	71
2394	Canvas Products	0	2	0	0	1	9	2	14
2431	Millwork Plants	4	1	0	0	10	23	5	43
2699	Converted Paper Prod.	1	1	0	0	3	1	3	9
2541	Office & Store Fixtures	2	1	0	0	5	8	0	16
2641	Paper Coating & Glasing	2	2	0	0	3	7	5	19
8061	Hospitals	22	2	16	0	3	2	6	51
3411	Tin Cans	0	0	0	0	2	15	12	29
3271	Concrete Products	0	1	0	0	0	3	3	7
2896	Comp. & Liquified Gases	0	1	0	0	1	9	7	18
5311	Department Stores	3	20	1	0	3	7	3	37
0113	Vegetable Farms	0	0	0	8	1	2	2	13
1791	Structural Steel Erection	0	0	0	0	8	4	4	16
3312	Steel Works & Roll. Mill	0	0	0	0	15	15	9	39
3664	Tel. & Tel. Equipment	0	1	0	0	2	6	1	10
4521	Air Carriage	1	0	0	0	26	5	1	33
3811	Scientific Instruments	1	0	0	0	12	5	0	18
3522	Agricultural Machinery	0	0	0	0	3	9	0	12
	Totals.....	46	58	24	8	127	197	95	560

* Standard Industrial Classification Manual, Bur. of the Budget. Wash. 1945

"During the second stage of training, the field analyst rated 25 jobs in three different industrial establishments on the basis of direct observation of those jobs. These ratings were correlated with ratings of the same jobs made by a reviewing analyst under identical conditions. Correlations between Strength ratings was 0.94. For the remaining factors, the chi square test indicated a significance of agreement at better than the 0.001% level. Reliability in terms of applying manual procedures was deemed satisfactory, and the training was concluded."[1]

"Insofar as possible, all field ratings [for the 50 jobs] were reviewed and approved by plant administrative and supervisory personnel. Plant personnel retained one copy of the ratings, the field analyst retained a second copy, and the original was forwarded to Washington. Headquarters' ratings for these same jobs were then copied off onto the work sheets and returned to the field analyst only after the entire study had been received from the field.

Results

The field analyst performed the necessary statistical computation, while an outside agency* duplicated the statistical treatment. The strength factor, which is assumed to be continuous and normally distributed throughout the working population, was correlated by means of the Pearson r. Since the remaining factors were rated as critically required or not required, assumptions as to continuousness and normal distribution could not be applied (3). In addition a proportion of overlap correlation coefficient (2) was computed. The results are indicated in Table 2 (Figure 7).

The correlations appear to establish the fact that Physical Capacities and Working Conditions ratings made by trained analysts on the basis of occupational information may be used as confidently as though these ratings had been made on the basis of direct observation. Similar conclusions were reached in a related study concerned with the rating of Aptitudes (5). The same thought expressed there, that '...inferences generated either from direct observation or reading material are mediated through a system of concepts and it is in effect these concepts that are rated' may be operative here as well."[2]

*Community Studies Inc.

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[1] Newman, J. and Fine, S. A., A Journal of Applied Research, U.S.E.S., Volume 10, Number 2, Summer 1957, page 185

[2] Newman, J. and Fine, S. A., id., pages 187-188

Figure 7

TABLE 2

Correlation Between Ratings Based on Direct Observation and Ratings Based on Occupational Information (n = 500)

Factor	Chi Square Significance Level	Proportion of Overlap Coefficient
1 Strength	not calculated	(Pearson r = 0.71)
2 Climbing and Balancing	.001	.98
3 Stooping, Kneeling, Crouching and Crawling	.001	.89
4 Reaching, Handling, Fingering, and Feeling	.001	.98
5 Talking and Hearing	.001	.96
6 Seeing	.001	.81
2 Extremes of Cold plus Temperature Change	.001	1.00
3 Extremes of Heat plus Temperature Change	.001	.98
4 Wet and Humid	.001	.96
5 Noise and Vibration	.001	.86
6 Hazards	.001	.94
7 Fumes, Odors, Toxic Conditions, Dust, and Poor Ventilation	.001	.94

Practicability

The need for comprehensive and accurate physical requirements data for placement hardly needs much elaboration. Suitable matching of qualifications of workers with job requirements is essential not only for achieving optimum levels of productivity but to minimize dangers, hazards, and stresses which can result in inordinate costs and violation of safety regulations. Today, the accuracy of such information is especially essential to deal appropriately with so-called physically and emotionally handicapped individuals, who are considered in the same way as racial and ethnic minorities in equal employment opportunity legislation.

However, the problem of measuring and specifying the physical requirements of jobs and measuring the physical capacities of individuals for suitable matching is practically an impossible job for three major reasons. In the first place, measurement is extremely costly as well as very slow. In the second place, it is extremely difficult to determine all the physical factors that are relevant due to their number and changing environmental and technological conditions of jobs. Even more difficult is the third reason, namely, that individuals with varying degrees of interest, aptitude, temperament, training, etc., can marshal their personal resources differentially to overcome particular handicaps. Other than that it occurs, little is known how it occurs. It can even occur within the same individual under different motivational circumstances. This fact, in fact, places practically everyone in the category of "physically disabled for some jobs."

The reasons enumerated make it impractical to undertake extensive measurement. Far more practical is the use of carefully developed estimation techniques such as those described here and the inclusion of the data along with other occupational information in the descriptive material for the jobs. Such information not only adds to the screening criteria of the personnel staff, but properly presented to applicants, allows for self-selection.

The estimates described have been made for all the jobs defined in the Dictionary of Occupational Titles, Third edition, and have been found useful as a basic reference point by the Bureau of Hearings and Appeals in adjudicating Social Security claims for disability insurance. The Bureau has enlarged upon the work of the United States Employment Service by employing experts to do local field studies. Their experts have used the same manuals/reference points to make their estimates in the manner described above.

There is still another context within which we must consider the practicability of the estimation approach, namely, the dependence on doctors to make judgments about the suitability of individuals for particular types of work. Doctors are approached for this type of information largely because it is believed they have objective evidence on which to base their judgments. However, their measurements/judgments are narrow and limited to disease orientation. Furthermore, they know practically nothing about (a) the physical requirements of jobs or (b) how individuals marshal their total resources--i.e., balance strengths and weaknesses to meet particular job requirements.

"Since the disabled, like the fit, are ordinary human beings and do not constitute a minority group, we should attack the 'experts' who foster legislation requiring employers to hire the so-called disabled. We should attack them with just as great a force as the 'experts' are in truth attacking the disabled.

Moreover, we should call 'selective' placement by its first name. It is a fetter on the disabled. For employers tend to rebel when they think the disabled need special services and techniques. The fact is that all workers, so-called disabled or fit, require the same placement services. This means only 'placement,' and not 'selective placement' which carries the stigma associated with disability. For the same principles of 'placement' apply to all workers alike, disabled or not, each being placed according to his individual capacities and abilities. The individual abilities of the fit man require matching with work demands just as do those of the disabled, because, although a man may be physically fit medically speaking, in no way does this mean that he possesses the physical abilities for the work--he is most likely physically limited for hundreds of jobs, as is the disabled man. Moreover, the disabled are not freaks with a special problem. They neither want to be, nor should they be, considered as special individuals or as a distinctive group. They do not want, nor should they have, special placement services. The disabled both want to be and should be considered as the ordinary people they really are, each according to his individual capacities and abilities the same as anyone else. This means 'placement,' not 'selective placement.'"[3]

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[3]Hanman, B., Physical Capacities and Job Placement, Sweden: Nordisk Rotogravyr, 1951, pp. 62-63.